

AMENDMENTS TO THE CLAIMS

Independent claims 146, 148 and 149 are new, as is dependent claim 147. Dependent claims 2-4, 6-41, 68-72 and 81-85 are amended herein. Claims 1, 5, 42-67, 73-80 and 86-145 are canceled herein or were canceled previously.

146. (New) A method of preparing a medium with bubbles formed therein for immediate injection into a patient in connection with a medical procedure, the method including the steps of:

- (a) providing a source of a liquid and a source of a gas;
- (b) providing a bubble generator wherein the bubbles are created within the liquid to form the medium, said bubble generator having at least one inlet for receiving the liquid and the gas from said sources thereof and an outlet from which the medium is output;
- (c) providing a pressurizing device for pressuring the liquid for conveyance into said bubble generator and thereby for conveying therefrom the medium formed therein; and
- (d) providing a controller for controlling at least said pressuring device and said bubble generator through which to control (I) a rate of flow of the liquid and a rate of flow of the gas into said bubble generator via said at least one inlet thereof, (II) at least one property of the medium and (III) a rate flow of the medium from said bubble generator via said outlet thereof; and
- (e) communicating from said bubble generator via said outlet thereof the medium immediately after formation thereof so as to inject the medium into the patient in connection with the medical procedure at a rate controlled by said controller.

147. (New) The method of claim 150 wherein the step of injecting the medium immediately after formation thereof into the patient comprises using a catheter that is inserted into a suitable vessel of the patient and an associated tubing set through which the medium is communicated from said outlet of said bubble generator via said catheter into the patient.

1. (Canceled)

2. (Currently Amended) The ~~[system]~~ method of claim ~~[144]~~ 146 wherein said pressurizing device includes at least one of a gear pump, a peristaltic pump, a syringe pump and a centrifugal pump.

3. (Currently Amended) The ~~[system]~~ method of claim ~~[144]~~ 146 wherein the medical procedure is one of an imaging procedure carried out using an imaging unit and a therapeutic procedure.

4. (Currently Amended) The ~~[system]~~ method of claim ~~[144]~~ 146 wherein said controller ~~[also]~~ enables control of ~~[said] the~~ at least one ~~[operating parameter of said system]~~ property of the medium using at least feedback from an imaging unit used during the medical procedure.

5. (Canceled)

6. (Currently Amended) The ~~[system]~~ method of claim ~~[144]~~ 146, 3, or 4 wherein ~~[said operating parameters of said system]~~ the properties of the medium include composition of the medium, composition of the bubbles in the medium, concentration of the bubbles in the medium, size of the bubbles in the medium, rate of flow of the medium, volume of the medium administered, timing of the administration of the medium, sequencing of the administration of the medium, pressure of the medium, temperature of the medium, and viscosity of the medium.

7. (Currently Amended) The ~~[system]~~ method of claim ~~[144]~~ 146 further comprising using a fluid verification device disposed between said bubble generator and the patient, said fluid verification device for at least one of monitoring and changing at least one of ~~[said operating parameters of said system]~~ the properties of the medium.

8. (Currently Amended) The ~~[system]~~ method of claim 7 wherein said fluid verification device is capable of at least one of (i) detecting an unacceptably large amount of the gas and preventing administration thereof to the patient and (ii) destroying any of the bubbles having a diameter at least one of greater than, less than, within, and outside a predetermined range of sizes.

9. (Currently Amended) The ~~[system]~~ method of claim 7 wherein said controller at least one of communicates with and controls operation of said fluid verification device.

10. (Currently Amended) The ~~[system]~~ method of claim 7 wherein said controller controls operation of ~~[said system]~~ at least one of said pressurizing device and said bubble generator based at least in part on information from said fluid verification device.

11. (Currently Amended) The ~~[system]~~ method of claim ~~[144]~~ 146 wherein said bubble generator creates the bubbles by entraining the gas ~~[from a source thereof]~~ into ~~[a]~~ the flow of the liquid to form the medium.

12. (Currently Amended) The ~~[system]~~ method of claim 11 further comprising using a fluid verification device disposed between said bubble generator and the patient, said fluid verification device for preventing ~~[administration]~~ injection of the medium into the patient upon at least one of the ~~[a]~~ rate of flow of the medium dropping below a specified level and detecting that the medium contains an unacceptably large amount of the gas.

13. (Currently Amended) The ~~[system]~~ method of claim ~~[144]~~ 146 wherein said bubble generator comprises:

- (a) an enclosure within which to agitate the liquid in presence of the gas; and
- (b) a means for disrupting an interface between the liquid and the gas, said disrupting means being responsive to a control signal from said controller by agitating said interface thereby creating the bubbles of the gas within the liquid.

14. (Currently Amended) The ~~[system]~~ method of claim ~~[144]~~ 146 wherein said bubble generator comprises:

- (a) an enclosure within which to agitate the liquid in presence of the gas;
- (b) a mechanism for agitating associated with said enclosure, said mechanism being responsive to a control signal from said controller by agitating an interface between the liquid and the gas thereby creating the bubbles of the gas within the liquid; and
- (c) a filter disposed proximate said outlet for removing from the medium any of the bubbles having a diameter greater than a predetermined size.

15. (Currently Amended) The ~~[system]~~ method of claim ~~[144]~~ 146 wherein said bubble generator comprises:

- (a) an enclosure within which to place the liquid in presence of the gas;
- (b) two disks disposed in said enclosure, said disks separated by a gap of a preset thickness and capable of being spun;
- (c) a mechanism for spinning said disks, said mechanism being responsive to a control signal from said controller by spinning said disks thereby compelling the liquid to flow into said gap resulting in creation of the bubbles of the gas within the liquid; and
- (d) a filter disposed proximate said outlet of said enclosure for removing from the medium any of the bubbles having a diameter greater than a predetermined size.

16. (Currently Amended) The [~~system~~] method of claim [~~144~~] 146 wherein said bubble generator comprises:

- (a) an enclosure within which to place the liquid in presence of the gas;
- (b) a stirring element disposed in said enclosure;
- (c) a mechanism for moving said stirring element, said mechanism being responsive to a control signal from said controller by moving said stirring element thereby causing the creation of the bubbles of the gas in the liquid; and
- (d) a filter disposed proximate said outlet of said enclosure for removing from the medium any of the bubbles having a diameter greater than a predetermined size.

17. (Currently Amended) The [~~system~~] method of claim 16 wherein said stirring element comprises multiple small wires.

18. (Currently Amended) The [~~system~~] method of claim [~~144~~] 146 wherein the liquid is supersaturated with the gas under pressure and has nucleation materials therein, with said bubble generator comprising a nozzle such that as the liquid passes therethrough the pressure of the liquid decreases causing the bubbles of the gas to form on the nucleation materials and come out of and entrain with the liquid, thereby forming the medium.

19. (Currently Amended) The [~~system~~] method of claim 18 wherein the nucleation materials comprise at least one of particles and chemicals.

20. (Currently Amended) The [~~system~~] method of claim [144] 146 wherein the liquid is supersaturated with the gas under pressure as the liquid enters said bubble generator, with said bubble generator comprising a nozzle having a plurality of nucleation sites formed therein such that as the liquid passes through said nozzle and contacts at least one of said nucleation sites the pressure of the liquid decreases causing the gas to come out of solution, forming the bubbles that entrain with the liquid thereby forming the medium.

21. (Currently Amended) The [~~system~~] method of claim 20 wherein said nucleation sites take the form of pits formed in an inner wall of said nozzle.

22. (Currently Amended) The [~~system~~] method of claim 20 wherein said nozzle is cylindrical in shape.

23. (Currently Amended) The [~~system~~] method of claim 20 wherein said nozzle comprises plates attached together to form a pipe, with at least one of said plates bearing said nucleation sites.

24. (Currently Amended) The [~~system~~] method of claim [~~144~~] 146 wherein said bubble generator comprises:

- (a) an enclosure within which to place the liquid in which the gas is dissolved; and
- (b) a device, controlled by said controller, to apply energy to the liquid to create localized regions of gas supersaturation thereby enabling creation of the bubbles of the gas within the liquid to form the medium.

25. (Currently Amended) The [~~system~~] method of claim 24 wherein said localized regions of gas supersaturation comprise regions of reduced pressure created by at least one of mechanical motion, an oscillatory pressure component, and an oscillatory flow component.

26. (Currently Amended) The [~~system~~] method of claim [~~144~~] 146 wherein said bubble generator comprises:

- (a) an enclosure within which to place the liquid in which a gas is dissolved; and
- (b) a transmitter for transmitting ultrasonic energy into the liquid to cause cavitation therein thereby enabling creation of the bubbles of the gas within the liquid to form the medium.

27. (Currently Amended) The [~~system~~] method of claim [~~144~~] 146 wherein said bubble generator comprises:

(a) a liquid flow path for receiving via said at least one inlet the liquid from said pressurizing device; and

(b) a gas flow path in communication via said at least one inlet with [a] said source of the gas for directing the gas received therefrom to said liquid flow path;

with said liquid and said gas flow paths constituting a gas-liquid interface assembly such that said liquid flow path channels the liquid received from said pressurizing device to an intersection with said gas flow path to entrain the gas emanating therefrom as the bubbles, thereby forming the medium for communication from said outlet.

28. (Currently Amended) The [~~system~~] method of claim 27 wherein said controller operates said pressurizing device and said source of the gas to produce an oscillatory component to the flow within at least one of the gas flowing in said gas flow path and the liquid flowing in said liquid flow path.

29. (Currently Amended) The [~~system~~] method of claim 27 wherein said bubble generator comprises an array of said gas-liquid interface assemblies.

30. (Currently Amended) The [~~system~~] method of claim 27 wherein said bubble generator further comprises a fluid flow path for receiving a second liquid from said pressurizing device and for channeling the second liquid received therefrom into the liquid into which the gas has been entrained, thereby further forming the medium for communication from said outlet.

31. (Currently Amended) The [~~system~~] method of claim 30 wherein said bubble generator comprises an array of said gas-liquid interfaces.

32. (Currently Amended) The [~~system~~] method of claim [~~144~~] 146 wherein said bubble generator comprises:

(a) a gas introduction plate having a plurality of gas inlets in communication with [a] said source of the gas via said at least one inlet; and

(b) a liquid flow path for receiving via said at least one inlet the liquid from said pressurizing device and for channeling the liquid received therefrom over said gas introduction plate to entrain as the bubbles the gas emanating from said gas inlets, thereby forming the medium for communication from said outlet.

33. (Currently Amended) The [~~system~~] method of claim 32 wherein said controller operates said pressurizing device and said source of the gas to produce an oscillatory component to the flow within at least one of the gas flowing in said gas inlets and the liquid flowing in said liquid flow path.

34. (Currently Amended) The [~~system~~] method of claim 32 wherein said bubble generator further comprises a secondary plate disposed a predetermined distance apart from said gas introduction

plate between which the liquid is channeled by said liquid flow path, said predetermined distance being selected to affect a size of the bubbles so entrained.

35. (Currently Amended) The ~~[system]~~ method of claim 34 wherein said secondary plate has a plurality of gas inlets by which the gas is further so entrained by the liquid flowing in said liquid flow path.

36. (Currently Amended) The ~~[system]~~ method of claim ~~[144]~~ 146 wherein said bubble generator comprises:

(a) a tube having a plurality of gas inlets defined in a wall thereof and one end for receiving the liquid from said pressurizing device, with said gas inlets adapted for communication via said at least one inlet with ~~[a]~~ said source of the gas;

with said tube for channeling the liquid received from said pressurizing device over said gas inlets to entrain the gas emanating therefrom as the bubbles, thereby forming the medium for communication from said outlet.

37. (Currently Amended) The ~~[system]~~ method of claim 36 wherein said controller operates at least one of said pressurizing device and said source of the gas to produce an oscillatory component to the flow of at least one of the liquid and the gas.

38. (Currently Amended) The [~~system~~] method of claim [~~144~~] 146 wherein said bubble generator comprises:

(a) a chamber defining a plurality of gas inlets in communication with [a] said source of the gas via said at least one inlet; and

(b) a liquid flow path defined within said chamber;

with said liquid flow path for channeling the liquid received from said pressurizing device via said at least one inlet to an intersection with said gas inlets to entrain the gas emanating therefrom as the bubbles, thereby forming the medium for communication from said outlet.

39. (Currently Amended) The [~~system~~] method of claim 38 wherein said controller operates at least one of said pressurizing device and said source of the gas to produce an oscillatory component to the flow of at least one of the liquid and the gas.

40. (Currently Amended) The [~~system~~] method of claim [~~144~~] 146 wherein said bubble generator comprises:

(a) a first member having outer and inner sides, hydrophobic and hydrophilic, respectively, with a plurality of inlet holes extending therebetween, said outer side of said first member for channeling the [~~first~~] liquid over said inlet holes;

(b) a second member having inner and outer sides, hydrophobic and hydrophilic, respectively, with a plurality of outlet holes extending therebetween, said outer side of said second

member for channeling the liquid over said outlet holes, said inner sides of said first and said second members being separated by a gap and arranged so that each of said inlet holes aligns with one of said outlet holes, said gap for channeling the gas between said first and said second members; and

(c) a means for generating droplets of the liquid such that each of said droplets is directed through one of said inlet holes, said outlet hole corresponding thereto and the gas present therebetween and into the liquid on said outer side of said second member thereby forming a bubble therefrom within the liquid to form the medium therefrom.

41. (Currently Amended) The [~~system~~] method of claim [~~144~~] 146 wherein said bubble generator comprises:

(a) a plate having a first surface and a second surface with an inlet hole extending therebetween, said first surface and a wall of said inlet hole being in contact with the liquid; and

(b) a heater in communication with said wall of said inlet hole to form an interface assembly therefrom; such that, upon application of a pulse of energy to said heater, said heater heats the liquid in said inlet hole to form a bubble of gas therefrom, the bubble moving from said interface assembly into the liquid flowing along said second surface to form the medium therefrom.

148. (New) A method of preparing a medium with bubbles formed therein for immediate injection into a patient in connection with a medical procedure, the method including the steps of:

(a) providing a source of a liquid and a source of a gas;

(b) providing a bubble generator in which to form the medium by creating bubbles of the gas within the liquid, said bubble generator having at least one inlet for receiving the liquid and the gas from said sources thereof and an outlet from which the medium is output;

(c) providing a pressurizing device for pressuring the liquid for conveyance into said bubble generator and thereby for conveying therefrom the medium formed therein; and

(d) providing a controller for controlling at least said pressuring device and said bubble generator through which to control (I) a rate of flow of the liquid and a rate of flow of the gas into said bubble generator via said at least one inlet thereof, (II) at least one of a size, a concentration and a composition of the bubbles created by the bubble generator within the liquid and (III) a rate flow of the medium from the bubble generator via the outlet thereof; and

(e) communicating from said bubble generator via said outlet thereof the medium immediately after formation thereof so as to inject the medium into the patient in connection with the medical procedure at a rate controlled by said controller.

149. (New) A method of preparing a medium with bubbles formed therein for immediate injection into a patient in connection with a medical procedure, the method including the steps of:

(a) providing a source of a first liquid;

(b) providing another source of at least one of a second liquid and a gas;

(b) providing a bubble generator wherein the bubbles are created using the gas and at least one of the first liquid and the second liquid to form the medium, said bubble generator having at least one inlet for receiving the first liquid and at least one of the second liquid and the gas from said sources thereof and an outlet from which the medium is output;

(c) providing a pressurizing device for pressuring the first liquid and at least one of the second liquid and the gas for conveyance into said bubble generator and thereby for conveying therefrom the medium formed therein; and

(d) providing a controller for controlling at least said pressuring device and said bubble generator through which to control (I) a rate of flow of the first liquid, a rate of flow of the second liquid and a rate of flow of the gas into said bubble generator via said at least one inlet thereof, (II) at least one property of the medium and (III) a rate flow of the medium from said bubble generator via said outlet thereof; and

(e) communicating from said bubble generator via said outlet thereof the medium immediately after formation thereof so as to inject the medium into the patient in connection with the medical procedure at a rate controlled by said controller.

42-67. (Canceled)

68. (Currently Amended) The [system] method of claim [42] 149 wherein said bubble generator comprises:

(a) a liquid flow path for receiving and channeling the first liquid; and

(b) a gas flow path for directing the gas to said liquid flow path;

with said liquid and said gas flow paths constituting a gas-liquid interface assembly such that said liquid flow path channels the first liquid to an intersection with said gas flow path to entrain the

gas emanating therefrom as the bubbles, thereby forming the medium [~~for communication~~]
communicated from said outlet.

69. (Currently Amended) The [~~system~~] method of claim 68 wherein said controller operates said [~~at least one~~] pressurizing device and said source of the gas to produce an oscillatory component to the flow within at least one of the gas flowing in said gas flow path and the first liquid flowing in said liquid flow path to promote uniformity in a size of the bubbles.

70. (Currently Amended) The [~~system~~] method of claim 68 wherein said bubble generator comprises an array of said gas-liquid interface assemblies.

71. (Currently Amended) The [~~system~~] method of claim 68 wherein said bubble generator further comprises a fluid flow path for receiving and channeling the second liquid into the first liquid into which the gas has been entrained, thereby further forming the medium [~~for communication~~]
communicated from said outlet.

72. (Currently Amended) The [~~system~~] method of claim 71 wherein said bubble generator comprises an array of said gas-liquid interfaces.

73-80. (Canceled)

81. (Currently Amended) The [~~system~~] method of claim [42] 149 wherein said bubble generator comprises:

(a) a first member having outer and inner sides, hydrophobic and hydrophilic, respectively, with a plurality of inlet holes extending therebetween, said outer side of said first member for channeling the first liquid over said inlet holes;

(b) a second member having inner and outer sides, hydrophobic and hydrophilic, respectively, with a plurality of outlet holes extending therebetween, said outer side of said second member for channeling the second liquid over said outlet holes, said inner sides of said first and said second members being separated by a gap and arranged so that each of said inlet holes aligns with one of said outlet holes, said gap for channeling the gas between said first and said second members; and

(c) a means for generating droplets of the first liquid such that each of said droplets is directed through one of said inlet holes, said outlet hole corresponding thereto and the gas present therebetween and into the second liquid thereby forming a bubble therefrom within the second liquid to form the medium therefrom.

82. (Currently Amended) The [~~system~~] method of claim [42] 149 wherein said bubble generator comprises:

(a) a housing having at least one cell chamber therein; and

(b) said at least one cell chamber defining therein a first liquid flow path, a second liquid flow path and a gas flow path, said first liquid flow path for receiving the first liquid, said second liquid flow path for receiving the second liquid, said gas flow path for receiving the gas;

wherein said gas flow path channels the gas received into an intersection of said flow paths at which the first and the second liquids meet so that, as a pulse of the second liquid arrives at said intersection, a bubble is (A) formed thereat from the second liquid and the gas with the second liquid forming a shell of the bubble and (B) conveyed through said first liquid flow path into a flow of the first liquid outside of said cell chamber thereby forming the medium ~~[for communication]~~ communicated from ~~[the]~~ said outlet of said bubble generator.

83. (Currently Amended) The ~~[system]~~ method of claim ~~[42]~~ 149 wherein said bubble generator comprises:

(a) a plate having a first surface in contact with ~~[a]~~ the first liquid and a second surface in contact with ~~[a]~~ the second liquid with an inlet hole extending therebetween; and

(b) a heater in communication with a wall of said inlet hole to form an interface assembly therefrom; such that, upon application of a pulse of energy to said heater, said heater heats the first liquid in said inlet hole to form a bubble of gas therefrom, the bubble moving from said interface assembly into the second liquid to form the medium therefrom.

84. (Currently Amended) The ~~[system]~~ method of claim 83 wherein the bubble incorporates components from the first liquid as it moves into the second liquid.

85. (Currently Amended) The [~~system~~] method of claim 84 wherein:

(a) the first liquid is a hydrophobic liquid and the second liquid is hydrophilic liquid;

(b) said first surface and said wall of said plate is hydrophobic and in contact with the hydrophobic liquid, with the hydrophobic liquid comprising a first fluid and a second fluid with the first fluid having a boiling point lower than the second fluid; and

(c) said second surface is hydrophilic and in contact with the hydrophilic liquid;

such that, upon application of the pulse of energy to said heater, said heater heats the hydrophobic liquid in said inlet hole to form the bubble of gas from the first fluid thereof with the second fluid thereof condensing and forming a shell of the bubble with the bubble moving from said interface assembly into the hydrophilic liquid to form the medium therefrom.

86-133. (Canceled)

134-139. (Canceled)

140-143. (Canceled)

144. (Canceled)

145. (Canceled)